

**PATENT APPLICATION**

**OVERBURDEN ROCK CORE SAMPLE CONTAINMENT SYSTEM**

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## OVERBURDEN ROCK CORE SAMPLE CONTAINMENT SYSTEM

### CROSS-REFERENCES TO RELATED APPLICATIONS

[0001] NOT APPLICABLE

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### STATEMENT AS TO RIGHTS TO INVENTIONS MADE UNDER FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

[0002] NOT APPLICABLE

10 REFERENCE TO A "SEQUENCE LISTING," A TABLE, OR A COMPUTER  
PROGRAM LISTING APPENDIX SUBMITTED ON A COMPACT DISK.

[0003] NOT APPLICABLE

[0004] This invention relates to a compression cell for soil or rock core samples for  
applying and restoring lithostatic or overburden pressure to soil or rock core samples  
15 extracted from wells drilled deep into the earth. Specifically, a method of applying lithostatic  
pressure to a core sample is disclosed along with the apparatus which effects the application.  
The cell which maintains the litho static pressure and the process of utilizing the cell and  
sample under essentially deep earth ambient conditions are set forth.

### BACKGROUND OF THE INVENTION

20 [0005] Underground rock pressures and underground fluid pressures differ radically.  
Underground rock pressures relate directly to overburden in and around the particular soil  
sample being tested. For example, in certain rock conditions where a sample is at a depth of  
about 10,000 feet, overburden pressures in the range to 8000 to 10,000 pounds per square  
inch may be experienced. Underground fluid pressures differ radically. As the soil usually  
25 defines paths through which fluid can flow, the fluid pressure is usually independent of the  
rock pressure. Taking the example of the core sample at 10,000 feet, and remembering the  
fluids have a density about one third of that of a rock, pressures in the range of 3000 to 4000  
pounds per square inch may be present.

[0006] Core samples are frequently extracted from deeply drilled the wells so that fluid flow properties within the rock of the core may be analyzed. Pore size, flow properties, capillary pressure and the like are all dependent upon the overburden pressure or lithostatic pressure upon a rock sample. If accurate testing of such core samples is to occur, the

5 lithostatic pressures must be re-created.

[0007] It is also known that the deeper one goes into the earth's mantle, the greater the temperature present in the ambient rock. Accordingly, if testing under the ambient conditions is to be re-created, it must be done under the same thermal conditions as well as lithostatic conditions as existed for the sample at its original depth within the earth.

10 [0008] It is known to use centrifuges in the analysis of such core samples. See for example O'Meara Jr. et al. US Patent 4,567,373, Goodwill US Patent 4,740,077, Christiansen US Patent 4,817,423, Chen et al. US Patent 5,328,440, Ragazzini et al. US Patent 5,351,525, Spinler et al. US Patent 6,415,649, Fleury et al. US Patent 6,185,985, and Goglin et al. US Patent 6,490,531. In none of these references is litho static pressure created independently of

15 fluid pressure.

### Discovery

20 [0009] I have come to the realization that for the realistic testing of drill core samples, at least the litho static pressures must be re-created on the sample before accurate testing can occur. Preferably, I re-create both litho static pressures and thermal temperatures before testing. Only after both the litho static and thermal ambient are re-created, is it possible to

conduct accurate testing.

### BRIEF SUMMARY OF THE INVENTION

[0010] A process for loading a centrifuge rotor with overburden pressure or lithostatic pressure onto a rock core sample is disclosed. A titanium containment cylinder closed at one

25 end forms the compression cell. A rubber liner closing one end of the containment cylinder also covers the sides of the containment cylinder. A core sample is placed interior of the liner so that the liner is between the containment cylinder and the core sample. A loading ring is utilized to compress the rubber liner within the containment cylinder over the placed core sample to uniformly compress the rubber liner and as a result the core sample from both ends

30 as well as the cylindrical sides. Compression of the loading ring occurs so that the rubber liner essentially acts as a fluid to apply lithostatic pressure to the core sample uniformly on all

sides. Provision is made to heat the core sample to ambient earth temperatures, preferably before compression occurs. A hydraulic press for applying the overburden or lithostatic pressure to the core sample is disclosed. Fluid inlet/outlets communicate through both ends of the containment cylinder to enable fluid measurements to be taken of the compressed core sample. The cell finds preferred use within a centrifuge or can be used independently for measurement of core sample fluid properties. Fluid, typically oil, gas, water, brine, or mixtures thereof, is passed through the core sample to determine hydrodynamic and hydrostatic characteristics of the rock core sample at the lithostatic temperature and pressure.

#### BRIEF DESCRIPTION OF THE DRAWINGS

10 [0011] Fig 1 is a perspective view in cross-section of a cell according to this invention illustrating an extracted core sample being compressed by a removable loading fixture with the rubber sleeve a centrally acting as a fluid for causing compression between the outer body of the containment cell and the inner and contained core sample;

15 [0012] Fig 2 is a sectional view of the cell of Fig 1 placed within a hydraulic press for applying or releasing the overburden or lithostatic stress on the core sample; and,

[0013] Fig 3 is a schematic of the cell according to this invention being utilized within the centrifuge.

#### DETAILED DESCRIPTION OF THE INVENTION

20 [0014] Referring to Fig 1, an overburden cell C is illustrated. Cell C is composed of an metal outer body 1 with rubber sleeve 8 containing rock core 4. Metal outer body 1 is cylindrical, closed at one and an open at the opposite end. Lower and upper metal end plugs 6, 7 which are equipped with fluid inlet/outlet ports 11 are within the interior of outer metal body 1. The reader will appreciate that the inlet/outlet ports 11 are typically larger than the 25 largest particle size of the rock core sample 4. Typically, when overburden pressures are applied, the solids form a compression dome over the port 11 which allows substantially unimpeded fluid communication into and out of cell C.

[0015] A push ring 2 at the open end of metal outer body 1 is used to compress the rubber sleeve when placed within a loading press. Rubber sleeve 8 acts essentially as a fluid on all 30 sides and one end of rock core 4. It applies the requisite overburden pressure on to rock core

4. Specifically, removable loading fixture 12 acts on push ring 2 to apply compression to rubber sleeve 8.

[0016] When pressure is applied to rubber sleeve 8 and rock core 4, locking closure 3 is screwed in after push ring 2 maintaining the pressure on the push ring. The axial loading nut 5 (5) is adjusted prior to pressurizing to adjust for minor changes in rock core length.

[0017] Anti-extrusion rings 9, 10 prevent the pressurized rubber sleeve from flowing into the opening between the outer body 1 and the end plugs 6, 7 when pressure is applied. The result is that rock core 4 as overburden pressure applied by rubber sleeve 8. By the expedient of adjusting the locking closure 3, the overburden or lithostatic pressure can be preserved on 10 rock core 4.

[0018] Referring to Fig 2, overburden cell C a shown placed within the heating jacket J. Typically, heating jacket J is raised to a temperature ambient to that of the rock core 4 at the depth from which it is originally extracted. Thereafter, the overburden pressure is applied by having a loading ram 20, actuated by hydraulic pump 22 with gauge 23. Pressure is applied 15 through loading ram 21 to removable loading fixture 12. Rubber sleeve 8 becomes fluid like and applies to rock core 4 the requisite overburden or lithostatic pressure. It will then be understood, that the core sample 4 is loaded with ambient overburden pressure and because of the heating previously described will also reside at ambient temperature. The reader will understand that upon cooling, cell C will relieve some of the pressure on rock core 4. By the 20 simple expedient of reheating the cell C, both the ambient temperature and lithostatic pressure can be restored.

[0019] During loading of stress on rubber sleeve 8, it is important to pre-heat the sample and sleeve assembly to the temperature at which the test will be conducted. The pressurizing system should be left at conditions for a period of time to allow for some plastic flow of the 25 sleeve into small voids and openings prior to locking in the rings and removing the system from the press. To remove the sample from the chamber it is necessary to re-apply the same stress to the rubber sleeve in order to unscrew the retaining ring.

[0020] The primary uses of the cell here disclosed is in a centrifuge. Referring to Fig 3, a centrifuge is schematically described in which a motor 30 drives rotor 32 about axis of 30 rotation 34. Here, two cells C are shown undergoing centrifugation with in centrifuge chamber 36. Real-time fluid volume changes can be measured through the respective cells C by strobe light 38 through view port window 39.

[0021] It will be just as well understood that the cell C can be utilized without placement into a centrifuge. Specifically, rock core 4 can either have fluid placed under static conditions within it or alternatively have fluid ambient to the rock core 4 removed from the core by a displacing fluid.

5 [0022] From the above specification, it will be understood that I disclose at least four separate areas of utility. First, I have realized that overburden or lithostatic pressure is substantially independent of hydrostatic pressure. This being the case, I disclose a process of placing lithostatic pressure (and even temperature) on a sample first and then measuring its fluid flow characteristics second.

10 [0023] Secondly, I utilize the rubber liner within my containment cell surrounding the core sample. This rubber liner acts essentially as a fluid and is able to uniformly impose on the core sample the ambient lithostatic pressure that the core sample has in its natural environment. Thus when fluid flow characteristics are measured, they can be measured at the original lithostatic pressure. It is also to be noted, that by preheating the core sample to the 15 temperature found at its original depth within the earth, I can more or less completely emulate the conditions under which the core sample was extracted in the first instance. There are certain hysteresis effects which result from the cycling of temperatures and pressures on a rock core sample. These I cannot completely eliminate. However, by the following the disclosed testing routine, these effects can be minimized.

20 [0024] Thirdly, I disclose an article. Simply stated, the cell without with the lithostatically loaded specimen is a useful article of commerce.

[0025] Finally, the cell combined with a hydraulic press is a patentable article.